September 1997 Highlights of the Pulsed Power Inertial Confinement Fusion Program

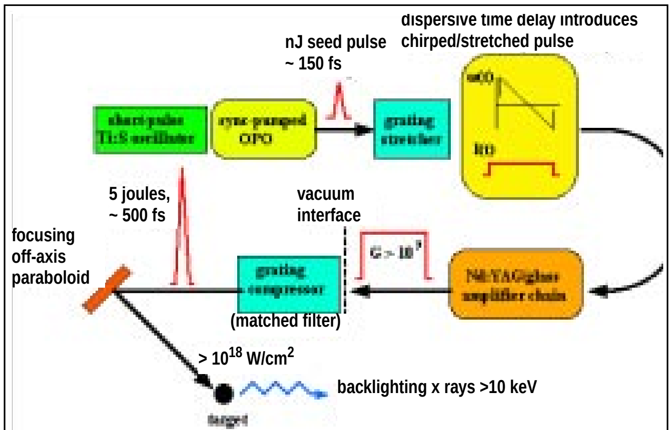

Fig. 1. Schematic of strategy for 500-fs, 5-J laser for backlighting on Z with >10 keV x rays.

Fig. 2. Pinhole image showing x rays emitted from 13-cm-long solid carbon anode of rod-pinch electron beam diode on Gamble-II Shot 6927. This represents another possibility for getting >10-keV x rays for backlighting. At the time of peak radiation, radiation from the rod tip is more that an order of magnitude greater than that at 4 cm and 8 cm from the tip, as measured by collimated pin diode detectors.

In July we reported a radiation temperature of 130 eV in a vacuum hohlraum on Z, as measured with an off-axis, 5-channel x-ray diode (XRD) array. That temperature had not been corrected for diagnostic hole closure, the angle at which the hohlraum wall is viewed, or for wall albedo (the absorption of x rays in the hohlraum wall). These issues have now been addressed. The largest correction factor, a 30% reduction in the diagnostic hole area by the time of peak hohlraum temperature, was determined by measuring the x-ray emission profile of the hole with a time-resolved x-ray pinhole camera. Numerical simulations at LANL give an additional correction factor for the viewing angle and wall albedo. The net result is a value of 146 eV for our best vacuum hohlraum configuration so far. New temperature diagnostics will be fielded in the next few months to better characterize the hohlraum temperature, x-ray spectrum, and spatial uniformity. Also, we will further optimize the hohlraum configuration and Z performance.

Of the 15 wire-array-driven Z shots this month, five were Defense Special Weapons Agency shots to determine whether higher x-ray yields are possible for radiation effects than those already obtained. Two SNL shots looked along the axis of a 2-µm-thick gold cylinder inside a wire array to assess the role of plasma fill inside the cylinder in obscuring the view by end-on diagnostics. Seven LLNL shots evaluated a dynamic hohlraum concept with either a high-density solid foam cylinder or one or more annular foam cylinders. A beryllium sleeve was within the innermost cylinder on the annular foam shots.

The axial package for the LLNL experiments includes a time-resolved, five-channel, variable-line-spaced reflection grating spectrometer. The diagnostic, often called the Angara spectrometer, was designed and first used by LLNL in imploding liner experiments driven by the 4-MA Angara-V z-pinch facility at Triniti. Its advantages are focus on a line instead of a circle and the ability to measure temperature vs. time with one instrument. Its disadvantages, compared to using XRDs plus a time-, space, and spectrally-resolved x-ray pinhole camera, are absence of 2-D spatial resolution and limited spectral resolution.

We are investigating a strategy for on-axis point-projection x-ray backlighting on Z, using a short-pulse, high-intensity (500 fs, 5 joule) laser to produce x rays with energies >10 keV (see Fig. 1). By using a chirped pulse amplification (CPA) scheme that is compatible with existing Nd:YAG glass amplifier architectures, we can extend the useful range of conventional nanosecond laser-driven plasma backlighters to obtain better penetration through the dense, hot material along the pinch axis near the time of stagnation. The nonlinear interaction of the intense laser field (focusable intensity of ~10^{18} W/cm^2) with a solid target or a dense cluster of gas atoms can create short, intense bursts of hard x rays in the form of continuum (bremsstrahlung) and line emission because of new coupling mechanisms intrinsic to the short-pulse format.

NRL has proposed an alternative way to produce the >10-keV x rays using rod pinch electron beam diodes (see Fig. 2). Gamble-I and Seven-Ohm-Line (SOL) experiments in the 1970s demonstrated the concept with single and multiple anode rods up to 30 cm long. Electrons propagate efficiently at ~1 cm/ns along the rod length; the tight pinch formation at the rod tip is further enhanced via a conical taper. Recent Gamble-II experiments with multiple parallel rods provide quantitative confirmation of the earlier experiments. A new, high-velocity (>>1 cm/ns), possibly-ion-free propagation mode has been demonstrated using hollow, low mass rods with solid tips. The electron endpoint energy, rod material, and geometry can be varied to meet different radiation source requirements for x-ray backlighting.

We are investigation the possibility of using multiple solid-state YAG lasers to trigger high-voltage gas switches in the pulse forming section of the proposed 60-MA, 16-MJ-radiation-yield z-pinch driver X-1 rather than the single KrF laser used on Z. A minature YAG laser made by Allied Signal was tested at Sandia on our Advanced Pulsed Power Research Module. The laser failed to meet the beam quality requirement and was returned to the manufacturer for reworking. Before returning the laser to Allied Signal, we interfaced and tested our fiber-optic-triggered Q-switch system for the module with the laser. A one-sigma jitter of 1 ns, adequate for triggering X-1 with a low module-to-module timing error, was demonstrated.

Contact: Jeff Quintenz, Inertial Confinement Fusion Program, Dept. 9502, 505-845-7245, fax: 505-845-7464, email: jpquint@sandia.gov

Highlights are prepared by Mary Ann Sweeney, Dept. 9502, 505-845-7307, fax: 505-845-7890, email: masween@sandia.gov.

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